



In-Situ Decontamination of Aquifers by Surfactant Solubilization of DNAPLs



Developer: Intera, Inc.
Contract Number: DE-AC21-92MC29111
Crosscutting Area: ESP

Subsurface
Contaminants
FOCUS AREA

Problem:

Contamination of aquifers by dense, non-aqueous phase liquids (DNAPLs) is a major factor in the failure of pump-and-treat systems to decontaminate these aquifers in reasonable time periods. Some liquid hydrocarbons are more dense than water so they sink readily into the aquifer system when released. DNAPL also have a very low solubility in water so they tend to exist as pockets at the location to which they have migrated. They dissolve slowly, leading to very slow rates of removal by conventional pump-and-treat operations. Because of their high carcinogenicity, the low levels found in the groundwater are still hazardous and exceed the maximum concentration limits set by the Environmental Protection Agency (EPA) for groundwater.

Solution:

A practical, cost-effective process to remove DNAPLs using in situ surfactant flushing as an advanced form of pump-and-treat, with chemically-enhanced solubilization (CES) of DNAPLs.

Benefits:

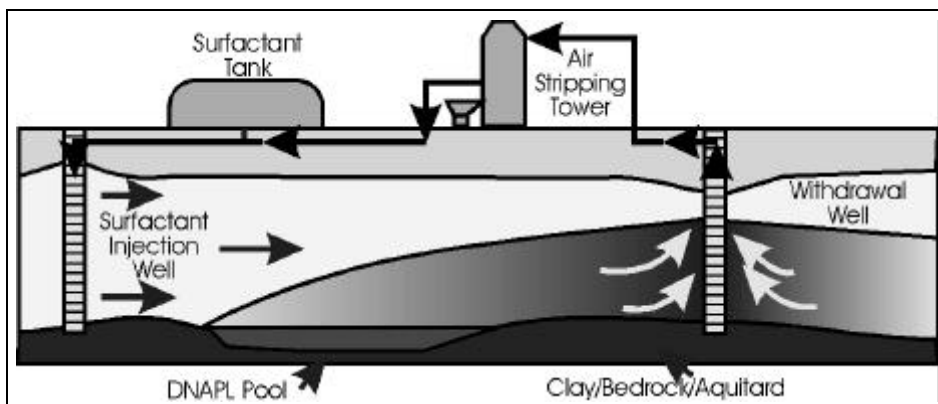
- Decreases significantly the number of pore volumes of groundwater that must be withdrawn from the aquifer
- Significant cost and time savings compared to current methods

Technology:

Chemically-enhanced solubilization

properties, respectively.

The solubilization mechanism, which is at the heart of the CES process, is the formation in groundwater of micelles, (i.e., colloidal clusters of nonionic surfactants) in which the molecules of the DNAPL are dissolved and then transported by



through surfactant flushing is, in essence, an enhancement of traditional pump-and-treat technology for groundwater contaminated with DNAPLs. Adding surfactants to the contaminated subsurface can greatly increase DNAPL extraction efficiency by increasing the apparent water solubility of the hydrophobic organic chemicals. Surfactants, or surface-active agents, have polar and nonpolar groups that exhibit hydrophilic and hydrophobic

the groundwater. In the field, CES works similarly to pump-and-treat operations except that dilute surfactant solutions are injected into the contaminated aquifer and withdrawn together with the solubilized DNAPLs for treatment. At certain characteristic concentrations, surfactants exhibit marked changes in several physical and chemical properties, (e.g., electrical conductivity, interfacial tension, and detergency). The concentration of the surfactant at



which these phenomena occur is known as the critical micelle concentration. At this concentration, the polar and nonpolar groups become oriented such that they form colloidal clusters of molecules in solution.

The clusters are characterized by the interfacing of the hydrophilic groups with the water molecules on the outside of the cluster, while the hydrophobic groups are arranged pointing towards the interior of the cluster. In the removal mechanism, the hydrophobic DNAPL molecules are solubilized inside the micellar assemblage of the surfactant and thus solubilized within the groundwater for pump-and-treat operations.

Project Conclusion:

The project was concluded in May 1997. Intera conducted a demonstration of surfactant enhanced aquifer remediation (SEAR) at the Portsmouth Gaseous Diffusion Plant from September 22 to 26, 1996. Initial conditions at the site had been evaluated in July 1996 using a partitioning interwell tracer test (PITT) and were used to design the surfactant flood. However, these conditions had evidently changed by August as trichloroethylene concentrations at two monitoring points rose by an order of magnitude. Hydraulic effects of nearby horizontal remediation wells could have caused the changes.

Preliminary results indicate that the surfactant flood resulted in the recovery of ~70% of the injected

surfactant, solubilization of ~50% of the DNAPL, and recovery of ~20% of the DNAPL. A post-flood PITT indicated a residual volume of ~2 gallons of DNAPL in the test zone of the aquifer. For comparison, tests under similar conditions at Hill Air Force Base in Utah demonstrated recovery of 98.9% of DNAPL (510 of 516 gallons). The results indicate some type of hydraulic interference during the surfactant flood. Recommendations call for greater site characterization in planning future SEAR applications and more extensive hydraulic control through use of specifically designed wells and well field configurations.

Contacts:

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